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Intraoperative ultrasound use in intracranial lesion surgery: An initial institution experience

Ultrasound use in intracranial lesion

Hasan Emre Aydın[1], İsmail Kaya[1], Nevin Aydın[2], Ceren Kızmazoğlu[4], Orhan Kalemci[3], Tayfun Aydın[4]
[1]Department of Neurosurgery, Dumlupınar University, Medical Faculty, Kutahya,
[2]Department of Radiological, Dumlupınar Univesity, Medical Faculty, Kutahya,
[3]Department of Neurosurgery, Dokuz Eylül University, Medical Faculty, Izmir,
[4]Department of Anesthesia and Reanimation, Dumlupınar University, Medical Faculty, Kutahya, Turkey

Abstract

Aim: Intraoperative ultrasound imaging is used in brain tumor surgery to identify tumor remnants. In this study, we aimed to evaluate the resection success of the brain lesions in different nature using ultrasonography (USG) and to analyze the effects of USG. Material and Method: USG assisted surgical resection was performed in 23 patients who had a preliminary diagnosis of brain tumors in our hospital. The resection borders and residual tumor tissue were checked intraoperatively by USG and postoperatively by magnetic resonance imaging in all patients. Results: The borders, cavities, and locations of operated 8 patients with glial tumors, 6 patients with meningiomas, 7 patients with metastases and 2 patients with intracranial abscesses were all determined with accuracy. Glial tumors were hypoechoic, and meningiomas were hyperechoic in USG, and the borders could be clearly distinguished. Difficulty in determining the exact border of the tumor was experienced only in tumors with large edema and diffuse nature. Gross total excision was achieved in all cases, and no additional neurological deficit was observed in any patient. Discussion: Color Doppler USG shows the relationship between the brain lesions and vascular structures, and this increases the success of the surgery. Another advantage of the USG is the real-time intraoperative determination of the resection degree, low cost, and the device being portable.

Keywords

Brain Tumor; Ultrasonography; Residual

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Corresponding Author: İsmail Kaya, Department of Neurosurgery, Dumlupınar University, Medical Faculty, Kutahya, Turkey.
T.: +90 2742652031 GSM: +905067282279 E-Mail: dr.ikaya85@gmail.com

Introduction

With quite a large spectrum, intracranial pathologies are diseases occurring with different clinical findings. Although the findings differ due to the location and dimension, the most common clinical findings are headache, epilepsy, and loss of strength. Using different characteristics for classifying intracranial tumors, WHO organized the tumors, named them according to the cell they are based on and thus designed them in a way that preliminary information can easily be acquired on treatment and survival [1].

Especially with the technological developments, new methods are used today in intracranial lesion diagnosis and treatment for preoperative planning, pathology findings and determining the correctness of selected approach [2]. The surgical aim is the complete lesion resection with a minimal neurological loss. Different diagnostic methods can be used such as direct graphies, which can be used in the diagnosis of calcified lesions, PET (positron emission tomography) and SPECT (single photon emission tomography) can be used for detection of metabolic tumor activation.Ultrasonography (USG) was developed by the American army in 1940 for medical use and was started to be used in intracranial lesions in the 1950s [3]. Sound waves in a higher frequency than the voices which can be heard by the human ear (> 20 kHz) are used in USG system. Piezoelectrical transducer series with 1-20 MHz frequency are used in medical USG systems [2]. Grey substance is observed to be slightly hyperechoic compared to the white substance in brain parenchyma. Tumors are generally hyperechoic in the USG. Acute edema is observed in hypoechoic form and is separated from mass lesion borders. Chronic edema cannot be visually distinguished in the US and may be confusing in intraoperative USG accompanied resections [2, 4].

With the improvements which have taken place in intraoperative USG since 1980, perfect image quality has been provided by improving poor resolution restricting its use, and today it is successfully used for demonstrating the location of intracranial tumors, biopsy, and cyst drainage [3,5]. Tumors (supratentorial, infratentorial, intraventricular), infections (abscess, empyema), foreign objects remaining under intracranial area following a trauma and vascular malformations are among the indications of cranial USG [5].

Our study aimed to discuss the advantages of intraoperative USG use in cases we operated in our clinic due to intracranial pathologies along with literature data and evaluate intraoperative US and preoperative magnetic resonance imaging (MRI).

Material and Method

Twenty-three patients operated in our clinic after referring with a pre-diagnosis of intracranial mass were included in our study. All patients had preoperative contrasted MRI (Siemens Magnetom 1.5 T). During surgery, all patients had a craniotomy, a dural puncture and the lesion was monitored using USG (Mindray Z5 Portable, Color Ultrasound System) transvaginal prob and linear prob. Sterile gel and saline solution was used to increase viscosity and prevent tissue damage while contacting brain tissue. No contrast material was used during the USG evaluation, and only the borders of the lesions were detected. A radiologist supported the team during the surgery for interpreting the images acquired. In preoperative period, MRI and images acquired through the intraoperative USG were compared.

Findings

Preoperative cerebral MRI was done in all cases (Figure 1). USG was used during surgery. Probs were sterilized. Among the patients we operated, 8 had a glial tumor, 6 had a meningioma, 7 had metastasis, and 2 had intracranial abscess. B mode imaging was used for lesion examination, and Doppler USG was used for vascularity evaluation (Figure 2). After craniotomy, the lesion borders were evaluated with USG after opening the dura mater. Images from different plans were intraoperatively taken for the patients. The borders, cystic components, and locations were detected for all lesions. Hyperechoic glial tumors and meningiomas were observed, and their borders were detected clearly (Figure 3). It was hard to distinguish the borders only in tumors which were diffused and had large edema (Figure 4). Total resection borders were acquired through intraoperative USG in all patients. MRI was done to control surgical resection borders of the patients during follow-up. The patients were discharged from the hospital in a healthy condition after the operation and were transferred to the oncology department to continue the suitable treatment if required according to the pathology result.

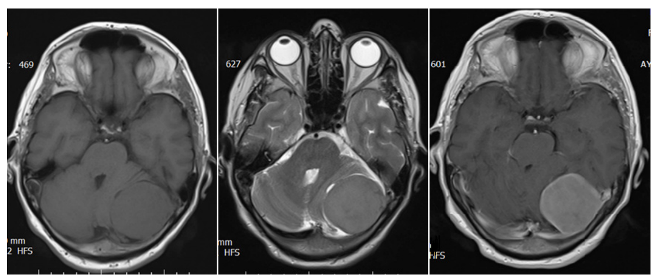

Figure 1. T1 AG'de hypointense (a), T2 AG' de hypointens (b), contrasty T1 AG'de diffuse contrasting (c) left cerebellar hemisphere and shift effected extradural with 4. ventricular compression, dural tail (arrow) lesion consistent with pathology meningioma was observed

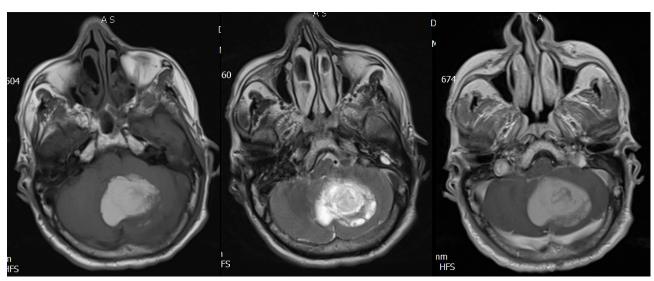

Figure 2. T1 MRI most of which are hyperintense (a), T2 MRI most of which are hyperintense(bcontrast-enhanced T1 MRI without contrast (c) hemorrhagic cystic lesions with hypointense components in all non-enhancing sequences extending from the left cerebellar hemisphere to the right side of the midline are present and pathology is compatible with cystic necrotic small cell lung metastasis.

Discussion

USG is frequently used for intraoperative intracranial lesion imaging [6]. While the US frequency range should be 5-7 Mhz in deep lesions, a range of 10-12 Mhz is commonly used in superficial lesions for a clear imaging quality [5]. In our study, we generally used transvaginal prob in a range of 5-8 Mhz for those with a deeper position. We used the prob with a linear range of 10-12 Mhz in superficial lesions.

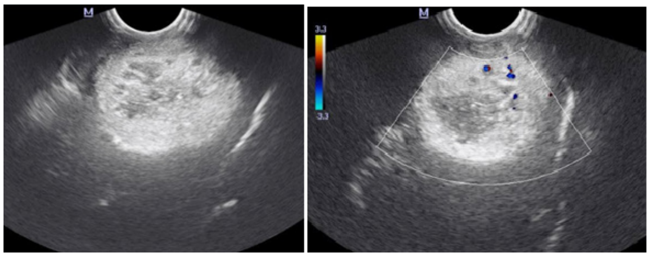

Figure 3. Intraoperative USG was performed with the transvaginal probe and hypoechoic components in the posterior fossa center with hyperechoic area (a), doppler ultrasound multi-level mild-blooded (b) mass lesion was observed.

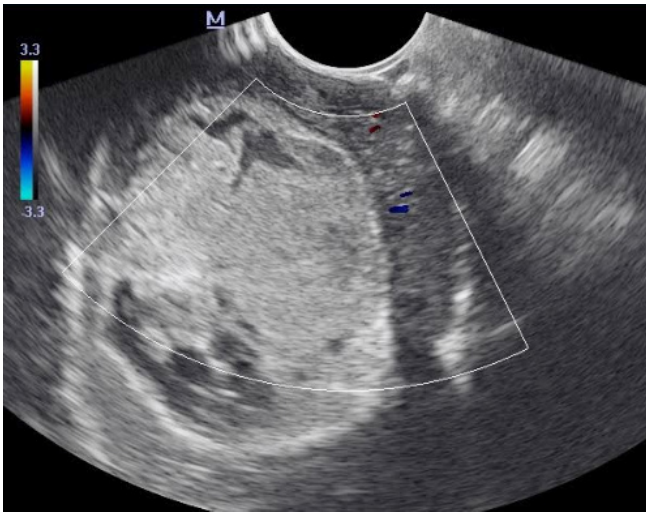

Figure 4. Intraoperative US examination with transvaginal probe showed no postoperative fossa blood supply, a large proportion of heterogeneous hyperechoic hemorrhagic mass lesions were observed.

Even though neuronavigation is a frequently used method in neurosurgical practice, it is not as effective as USG since the location would change during the excision of shift-affected lesions as the planning is done before surgery. As it provides instant visualization, USG is not affected by this change and is advantageous than neuronavigation [2, 3, 7]. USG is not affected by the location changes of tissues during surgery and after resection and this is an important advantage of USG but if craniotomy cannot be made in lesion border, a clear image cannot be provided as the prob movement would be limited [5]. Craniotomy field was satisfactory in our cases and no condition to prevent prob movement occurred. In another study showing the superiority of USG over neuronavigation, while there was no targeting error in the intraoperative USG group in the patients, it was present in 5 patients in neuronavigation group [8]. In another study showing the efficiency of intraoperative USG, 78 patients who had intracranial metastasis were operated, and intraoperative USG was used in 35 of these patients. In the evaluation made using Karnosfky scale in the postoperative period, it was observed that intraoperative USG use improved Karnosfky scale in the post-operation period and decreased residual tissue amount [9]. One of the most important advantages of supporting the surgery is increasing the quality of living for our patients after the surgery. In addition to cranial metastases, in series where intraoperative USG is used for low and high-grade glial tumor imaging, they showed that the tumor tissue is clearly separated from the normal tissue in B mode imaging and use of intraoperative USG provided a surgical advantage in intracranial surgery [10-12].

Intraoperative USG is used to determine the tumor localization and the shortest and safest way to reach the tumor in pediatric cases, especially in solid and cystic lesion distinction. In a series of 25 supratentorial and intratentorial lesions, use of intraoperative USG was shown to be an efficient method for border distinction of tumor tissue and healthy brain tissue [13]. In another study on a pediatric patient group, it was shown that the use of intraoperative USG was a faster and more affordable method compared to MRI [14].

The use of USG in residual tissue evaluation due to the imaging quality deficiency was limited before, but today it can prove optimal evaluation in residual tissue with the technological developments and imaging quality improvements [7].

Information can be provided on the vascularity of the present lesion with Doppler USG through instant visualization, and thus surgical area coagulation can be provided more easily during surgery [5].

Mair et al. intraoperatively used USG in a series of 105 patients and made a practical classification. Lesions were divided into four groups in this classification. Phase 3 lesions were defined and separated from the normal tissue clearly, Phase 2 lesions were defined clearly but were not separated from the normal tissue with a clear border, Phase 1 lesions were hardly defined and not separated with a clear border, and Phase 0 lesions were undefined. There were no undefined lesions in our study when the available classification was used, and it was observed that the borders of 8 lesions were intraoperatively determined and defined clearly in similar ratios (nearly 40%) [3]. In a study on a biopsy series of 100 patients not suitable for surgical resection, it was shown that USG use during operation didn't decrease operation-related complications in intracranial biopsies [15].

In a series of 81 patients in which three-dimensional USG was used, diagnostic images close to preoperative MRI were acquired due to intraoperative use [7]. In another series of 90 patients, the presence of concurrent vascular structures was demonstrated using intraoperative doppler USG in addition to three-dimensioned USG support [16]. Successful results were acquired in demonstrating tumor borders in studies using contrast-enhanced USG in the intraoperative imaging of intracranial pathologies [17,18]. Intraoperative three-dimensional and contrast-enhanced USG applications were widespread with the improving technology and provided a chance to provide instant visualization on preoperative imaging and give information on the residual tissue.

Results

Borders and vascularity of intracranial lesions were detected with USG extensively used in our hospitals. For USG, cost-efficiency, portability, and interpretability by an experienced team even in peripheral institutions compared to other imaging methods supported us during operation. It also provides total lesion excision without any residual tissues and surrounding healthy tissue damage due to the determination of surgical borders.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of

the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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